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Preliminary results on the growth and survival of the polychaete *Nereis diversicolor* (O. F. Müller, 1776), when fed with faeces from the carpet shell clam *Ruditapes decussatus* (L., 1758)

F. M. Batista[1], *P. Fidalgo e Costa*[2,3], *D. Matias*[1], *S. Joaquim*[1], *C. Massapina*[1], *A. M. Passos*[2], *P. Pousão Ferreira*[1] *and L. Cancela da Fonseca*[1,2]

[1] Ipimar/Cripsul, Av. 5 de Outubro, P-8700-305 Olhão, Portugal. E-mail: fmbatista@yahoo.com
[2] Imar/Laboratório Marítimo da Guia, Faculdade de Ciências de Universidade de Lisboa, Estrada do Guincho, P-2750-374 Cascais, Portugal
[3] Escola Superior de Educação João de Deus, Av. Álvares Cabral, 69, P-1269-094 Lisboa, Portugal

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ABSTRACT

The growth and survival of the polychaete *Nereis diversicolor* (O. F. Müller, 1776) fed on faeces of the carpet shell clam *Ruditapes decussatus* (L., 1758) were studied under controlled temperature and salinity conditions. Juvenile worms were fed with clam *R. decussatus* faeces in the presence or absence of sediment during 65 days. Starvation treatments were tested as a control.

The results of the present study show that the worms were able to grow using the clam faeces in the presence or absence of sediment. However, the worms from the trials with sediment showed a higher survival rate and biomass production than those from the trials in which no sediment was used. These findings suggest that a suspension of bivalve faeces can be used in the rearing of juvenile *N. diversicolor* in an integrated polyculture system.

Keywords: *Nereis diversicolor, Ruditapes decussatus*, faeces, sediment, polyculture.

RESUMEN

Resultados preliminares sobre el crecimento y la supervivencia del poliqueto* Nereis diversicolor *(O. F. Müller, 1776) alimentado con heces de almeja* Ruditapes decussatus *(L., 1758)

El crecimiento y la supervivencia del poliqueto Nereis diversicolor *(O. F. Müller, 1776) alimentado con heces de almeja* Ruditapes decussatus *(L., 1758) fueron estimados bajo condiciones controladas de temperatura y salinidad. Los poliquetos juveniles fueron alimentados con heces en presencia y ausencia de sedimento durante 65 días. Como control se aplicaron tratamientos de ayuno.*

Los resultados sugieren que los poliquetos crecieron usando las heces como única dieta en presencia y en ausencia de sedimento. Es más: los poliquetos de los ensayos con sedimiento mostraron supervivencia y producción de biomasa mayores que aquéllos en que no se utilizó sedimiento. Los resultados sugieren que se puede usar una suspensión de heces procedentes de bivalvos en el cultivo de juveniles de N. diversicolor *en un sistema de policultivo integrado.*

Palabras clave: Nereis diversicolor, Ruditapes decussatus, *heces, sustrato, policultivo.*

INTRODUCTION

One of the main problems in aquaculture is their sewage effluent, which implies both a major impact on the environment and an organic enrichment of the bottoms which receive the discharges. In bivalve hatcheries, a considerable amount of faeces are produced every day. The integration of organisms belonging to the detrital trophic level has been seen as a strategy to eliminate the build-up of detrital wastes characteristic of simple food chains in aquaculture (Tenore, Browne and Chesney, 1974).

The polychaete *Nereis diversicolor* (O. F. Müller, 1776) has a wide geographic distribution and can be found as far south as Morocco (Gillet, 1993) and as far north as Scandinavia, in the cold and brackish Baltic Sea, as well as in the warm and hypersaline lagoons of the Black Sea (Mettam, 1979). This species has been described as an omnivore which can shift from predatory/surface deposit-feeding to suspension feeding (Riisgård, 1991; Fidalgo e Costa, Narciso and Cancela da Fonseca, 2000), also able to obtain nourishment by coprophagy (Bradshaw *et al.*, 1990). The present study was carried out in order to evaluate the survival, growth and feed utilization of *N. diversicolor* juveniles fed with faeces from the carpet shell clam *Ruditapes decussatus* (L., 1758). We also assessed the viability of rearing this polychaete with and without sediment, which represents a possible difficulty in the integration of both cultures.

MATERIALS AND METHODS

Hatchery-reared *N. diversicolor* juveniles from the Tavira Shellfish Hatchery Station of the Portuguese Institute for Fisheries and Sea Research (Ipimar) were used in this experiment.

Worms with a mean wet weight (SE) of 11.7 (0.9) mg were randomly stocked in circular plastic containers (50 cm^2), five animals each, with four replicate containers per treatment. Worms were fed three days a week for a period of 65 days with a suspension of faeces from *R. decussatus*. The clams had been fed with the microalgae *Isochrysis* aff. *galbana* (Clone *T*-ISO). Fresh faeces were collected and immediately given to the worms, and a subsample from each feeding was taken for chemical analysis. Worms were reared in the presence or absence of sediment, and starvation treatments were tested as a control. Records were kept of the quantity of faeces supplied to the groups of worms. The feed efficiency ratio (FER) was calculated using the formula: FER = wet weight gain (g) /dry weight of faeces fed (g).

The sediment used in the experiments was natural sand, since good growth results had been obtained by Fidalgo e Costa (1999) using this kind of sediment. The sand was previously dried in a muffle oven at 450 °C for 24 h, in order to eliminate all organic matter, and placed in a layer 4 cm deep in the containers. Sediment samples were collected for grain size determinations. Sand was separated through dry sieving to determine the proportion of each fraction, according to the Wentworth scale.

To avoid the accumulation of catabolic products, water was changed every week with a mixture of deionised water and natural ultraviolet-treated sea water. Temperature (mean ± SD) and salinity were maintained at 20 ± 0.6 °C and 18, respectively. Initial and final wet weights of worms were determined after 24 h of starvation to empty the gut and 2 min drainage on absorbent paper. Dry matter content of the suspension of faeces was determined by drying at 80 °C for 24 h, and ash content by burning in a muffle oven at 450 °C for 24 h. Protein content was determined according to the method of Shakir *et al.* (1994).

Homogeneity of variance of the data was tested using Cochran's test. Survival data was square root-arcsine transformed, and biomass data log transformed prior to analysis. Data from the different treatments were compared with a two-way analysis of variance (anova). The results were considered significant at $P < 0.05$ (Zar, 1984).

RESULTS

The sediment used in these experiments was mainly medium (49.5 %) and fine (49.8 %) sand. The organic matter content of the faeces from *R. decussatus* was 510 mg g^{-1}, of which 6.5 % was protein (ash-free dry weight). The largest fraction of the protein content of the faeces fed to the worms can be attributed to the pseudofaeces, since they are mainly composed of intact microalgae cells.

With the clam faeces suspension as their sole diet, the polychaetes thrived, both in the presence or absence of sediment (figure 1). However, worms reared

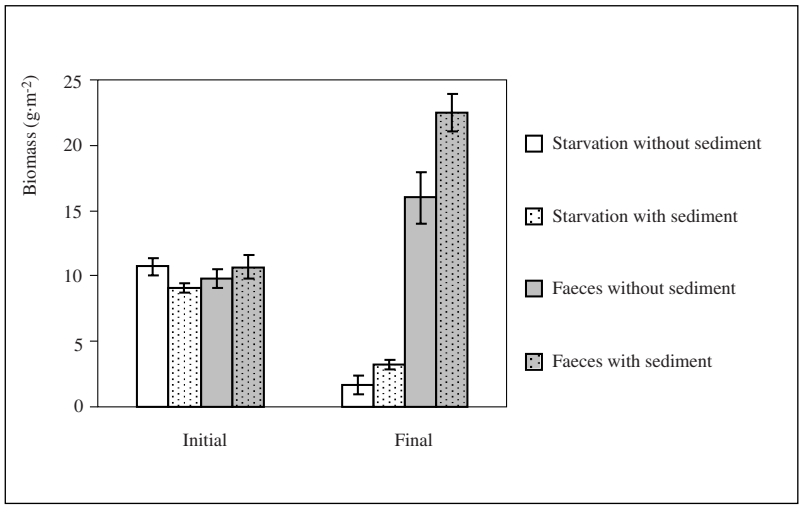

Figure 1. Initial and final biomass of *N. diversicolor* fed with clam faeces and starved for 65 days in the presence and absence of sediment. Values are the mean ± SD of four replicate groups (n = 4) of 5 worms each

with sediment showed a significantly higher biomass than those reared without it (table I and figure 1).

Survival was also significantly higher in worms reared with sediment (table I and figure 2). The feed efficiency ratio for the worms reared with sediment was 0.48, whereas the ratio for those without sediment was 0.25.

DISCUSSION

It is known that some species of polychaetes can use the faeces of different animals as a food source. Bradshaw *et al.* (1990) demonstrated that the polychaete *N. diversicolor* was able to assimilate very efficiently the lipids present in the faeces of the crus-

Tabla I. Results of the analysis of variance to test the influence of sediment (presence or absence) and feeding regimes (clam faeces and starvation) on survival and biomass of *N. diversicolor* after 65 days of rearing. (df): degrees of freedom; (F): calculated F statistic; (P): probability level; (ns): no significant (P > 0.05)

Source of variation	df	Survival		Biomass	
		F	P	F	P
Feeding regime	1	11.60	< 0.01	105.62	< 0.001
Sediment	1	28.14	< 0.001	6.75	< 0.05
Interaction	1	0.95	ns	0.53	ns

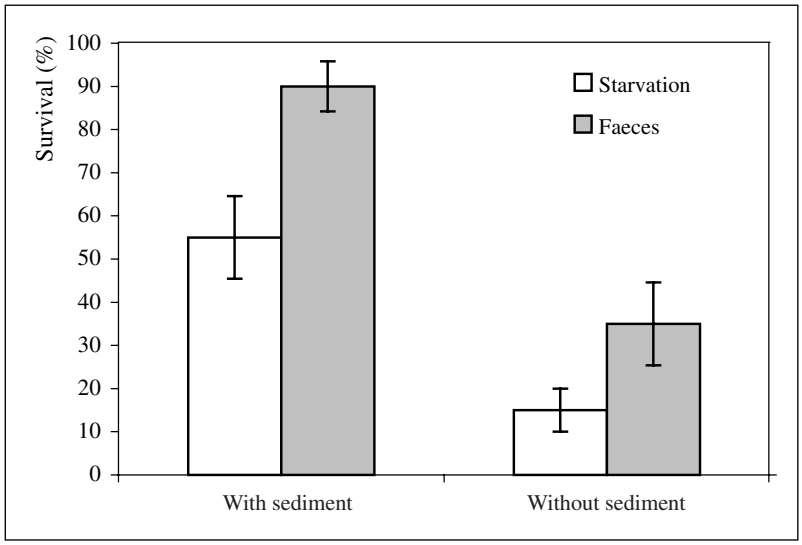

Figure 2. Survival of *N. diversicolor* fed with clam faeces and starved for 65 days in the presence and absence of sediment. Values are the mean ± SD of four replicate groups (n = 4) of 5 worms each

tacean *Neomysis integer* (Leach). Working with the polychaete *Perinereis nuntia vallata,* Honda and Kikuchi (2002) reported that this species was able to feed on the faeces of the fish *Paralichthys olivaceus*, converting half of the nitrogen ingested into worm body tissue. The results of the present study suggest that the faeces excreted by the clam *R. decussatus* contain organic matter that could be used by *N. diversicolor.* Moreover, the faeces could act as a substrate for bacteria and protozoans, increasing their nitrogen content, and which could be subsequently ingested by the worms. Tsuchiya and Kurihara (1979) reported that *Neanthes japonica* (Izuka) re-ingested its own faecal pellets after their nitrogen content increased through the action of micro-organisms. This could also happen with *N. diversicolor,* and needs further research.

The presence of sediment is important in the filter-feeding mechanism of *N. diversicolor*, since the burrowing worm spins a funnel-shaped mucous net-bag inside the tube and pumps water through the net in order to entrap food particles (Riisgård, 1991). Mucous nets were observed in the containers of the worms fed with faeces in the absence of sediment that also allowed them to capture suspended food particles.

Given the high initial density (1 000 indiv m^{-2}) used in the present experiment, the high mortality observed in the trials without sediment can be attributed to fighting and cannibalism. Although no significant interaction between sediment and feeding regimes on the survival of worms was observed ($P = 0.350$), the presence of sediment could have avoided encounters between worms fed on the suspension of faeces at the sediment surface, since the burrowed worms could obtain nourishment through filter feeding.

The results of the present study suggested that juvenile *N. diversicolor* are capable of using a suspension of clam faeces in the absence of sediment as a food source, although they could not grow and survive as well as could those fed in the presence of sediment. Although these results are preliminary, our findings suggest the feasibility of successful culture of this species in a polyculture system, reducing the organic matter produced and increasing the diversification of the crop production.

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